Study on the Effects of Reinforcing Chicken Feather Fiber (CFF) on Mechanical Properties of Polypropylene (PP)

by

Siti Khadijah Md. Rawi

Dissertation submitted in partial fulfilment of

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(Mechanical Engineering)

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Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Faiz Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2009

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

SITI KHADIJAH MD. RAWI

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ABSTRACT

Natural fibers have many advantages and potentially attractive to be used as reinforcement material. Various types of natural fibers have been researched and developed to replace the use of synthetic fibers with improved mechanical properties able for various applications. It is more economical if the natural fibers are used as reinforcement material for polymer matrix composites (PMC).

Chicken feather fiber (CFF) has good potential as reinforcement material. It is the objectives of this study to develop CFF reinforced polypropylene (PP) composites. The tensile properties were tested and compared to the original PP used as the control samples. CFF reinforced composite was prepared from raw chicken feather. The feathers were cleaned, soaked into organic solvent and dried until individual fiber is separated from each other. Later, the feathers are grinded to reduce the length so that the short fibers can be obtained, extruded and injection molded to produce test samples with different percentage of fiber volume fraction. There are 4 batches of samples which contain a range of volume fractions of CFF; 2.5 vol.%, 5.0 vol.%, 7.5 vol.% and 10 vol.%. After all the samples were prepared, tensile test was conducted. Stress-strain curve was produced from the test data and the results shown that the modulus of elasticity was improved to 12.9% at 5.0 vol.% of CFF and improvement in the stiffness of PP composite is observed at 2.5% vol. of CFF

The fracture surfaces of the tensile specimens for all CFF/PP reinforced composites were examined by using scanning electrone microscope (SEM). Images obtained from SEM provided an insight on the interactions between the fiber-matrix composite. It is proven as the fiber content increases, the presence of voids and broken fibers were also observed which resulted in reduced properties.

ACKNOWLEDGEMENT

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I would like to express my utmost gratitude to my supervisor for guiding me throughout the course of this project. His valuable advises and insights gave a huge contribution to me in order to complete the project within the time constraints and the desirable quality. I also would like to extend my utmost gratitude to all the material laboratory technicians who assisted me in setting up the equipments and conducting the tests required.

I would also wishes to extend my appreciation to my beloved parents, Mr. Md. Rawi Mahmud and Mrs. Ainon Merah, for their endless prays and to my dear colleagues for their support and friendship throughout the completion of this study.

Finally, a sincere heartfelt for anyone who had helped me directly or indirectly during this project. Thank you very much for your kindness. All the contributions are highly regarded and will always be remembered.

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CHAPTER 1
INTRODUCTION

1.1 Project Background

The development of low cost bio-fibers reinforced composites has gained much momentum in recent years. Bio-fibers are to be found in bones, plants, animals and all living things. In engineering practice, it is a common principle that two or more components may profitably combined to form a composite material so as to make best use of the more favourable properties of the components while silmutaneously mitigating the effects of some their less desirable characteristics [1]. The combination enhances properties of the matrix and also gives a tremendous cost saving new material.

There are number of methods for producing composite including injection molding process. All thermoplastics are, in principle, suiable for injection molding but since fast flow rates are needed, grades with good fluidity (high melt index) are normally preferrable [2]. It is the most common manufacturing process used to produce mass production of components with quite intricate shapes [3]. Thermoplastics are heated above the melting temperature in a barrel and forced into a closed die where it takes the shape of the mold cavity and solidifies [4]. Injection molding offers many advantages over other manufacturing methods including minimum losses from scrap providing since scrap pieces can be melted and reused with minimum finishing requirements [4].

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Composite materials are affected by the compatibility of phases. In fiber reinforced composites the composite strength is determined by the strength of fiber and by the ability of matrix to transmit stress to the fiber [5]. Transmission of stress to the fiber is affected by the fiber orientation (as opposed to stress direction), geometry (fiber length, fiber diameter) and interfacial bond between fiber and matrix [5]. A matrix is responsible in supporting the fiber, keeping them in a proper position, transferring the load to the fibers, protecting fibers from damage during the manufacturing process and preventing cracks in the fiber from propagating throughout the entire composite [6]. Hence, many factors must be considered when designing a fiber reinforced composite such as fiber length and diameter, fiber orientation, amount of fibers, properties of matrix and interfacial bonding between fibers and the matrix.

1.1 Background Study

This study aimed to investigate the effects of adding CFF as reinforcement material on mechanical properties of PP. The bio-fibers are favourable since they are abundant, cheap and provide an alternative to replace the non-environmentally friendly raw materials that are used today as reinforcement [5]. Composites will be prepared from various percentage of volume fractions of CFF used to reinforce PP. the dispersion of CFF fiber, tensile properties will be studied and compared with the original PP.

1.2 Problem Statements

Fiber reinforced polymer composites have received widespread attention because of their high specific strength and modulus. Composites commonly used high strength fibers such as graphite, aramid and glass in broad range of applications, from aerospace structure to automotive parts. However, this type of composites is imported from overseas and need high cost to produce it. This situation has led to the development of natural fibers.

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The development of natural fibers composites is expected to be more economical and cost effective than using the synthethic fibers. Although the natural fibers may not be as strong as carbon or aramid, they offer low production cost and biodegradability.

Natural fibers also provide vast supply since they are relatively inexpensive and abundantly available. Profound research has to be done to discover the suitability of CFF as reinforcement in polymer composites in order to produce more economical polymer composites.

1.3 Objectives

1. To develop and characterize CFF reinforced PP composite.
2. To study the effect of various volume fractions of reinforcing CFF on tensile properties of PP.
3. To study the microstructures of CFF/PP composites.

1.4 Scope of study

Study on the effect of reinforcing CFF on mechanical properties of PP is to be completed within the time frame given that is two semesters. The study is focused on processing and mechanical aspects of composites. The initial work is to get familiarized with polymer composites and gathered all the required information on processing the fiber reinforced composites and before the end of the first semester, the test specimens are prepared. During the second semester, the study focused on mechanical testing, gathering data, compared and studied with the existing PP composites. All the laboratory works are conducted in UTP and the successive microstructural studies are done using Scanning Electron Microscope (SEM).

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CHAPTER 2

LITERATURE REVIEW

2.1 Polypropylene

Figure 2: PP in pellet form

Thermoplastics commonly used for reinforcement with bio-fibers are polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyamides (Nylon 6 and 6, 6) [5]. PP is used widely for manufacturing purposes due to its low density, excellent processibility, good mechanical properties, high temperature resistance, excellent electrical properties, good dimensional stability and good impact strength [9].

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Table 2: Properties of commercial thermoplastic polymers [5]

Property	PP	LDPE	HDPE
Density (g/cm^3)	**0.899 – 0.920**	0.910 – 0.925	0.941 – 1
Melting Temperature, T_m (°C)	**160 – 176**	105 – 116	120 – 140
Tensile strength (MPa)	**26- 41.4**	4- 78.6	14.5- 38
Young's Modulus (GPa)	**0.95 -1 .776**	0.055 – 0.38	0.413 – 1.490
Elongation (%)	**15 – 700**	90 – 800	12 – 1000

2.2 Chicken feather composites

Typical advantages associated with short fibers in polymer matrices include design flexibility, high low-strain modulus, anisotropy in technical properties and stiffness, good damping and production economy [3]. Short fibers are also easier to process compared with continuous reinforcement since it can be processed in a manner similar to the matrix [3].

Generally, bio-fibers have a higher Young's Modulus compared to thermoplastics; thus make the polymer matrix composite stiffer [5]. The performance properties of natural fiber composites strongly depend on the fiber aspect ratio, fiber orientation, fiber-matrix interfacial, fiber dispersion and the nature of PP matrix and CFF itself [3].

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Fiber length is a critical parameter in short fiber reinforced composite [3]. The term 'short fiber' means that the fibers must not be too long since they might get entangled with each other leading to dispersion problem [3]. However, the fibers must not be too short either since this will results insufficient stress transfer area. The term 'composite' signifies that both PP matrix and CFF fiber must remain recognizable in the designed material [3].

2.3 Parameters influencing the characteristics of composites

Both fiber and matrix play an important role in improving the mechanical properties of composite. The resulted composite can be more sensitive to either the matrix properties or fiber properties. As an example, strength of a composite is more sensitive to matrix properties while the modulus of composite more sensitive to fiber properties [5]. The aspect ratio or volume fraction is the main parameter that governs the fracture properties [6]. Since a short fiber will be used, a critical fiber length is necessary for the fiber to develop its full stressed condition in polymer matrix for an efficient stress transfer between the fiber and the matrix which later improved the strength of the composite. Critical fiber length is where the stress transfer allows the fiber to be stressed to its maximum, has been used to predict the strength of the composites. The following expression is given by Broutman and Aggrawal [9].

$$\boxed{\frac{l_c}{d} = \frac{\sigma_{fu}}{2\tau_y}}$$

Where d= fiber diameter, σ_{fu}= ultimate film strength and τ_y= matrix yield stress in shear. It is emphasized that while comparing the fibers in different diameters, aspect ratio (*l*/d) is the main factor not the fiber length [3]. For good impact strength on the other hand, an optimum bonding level is required. The degree of adhesion, fiber pull out and energy absorption mechanisms are parameters that can influence the strength of short fiber composites [3, 5]. The mechanical properties of composites vary according to rule of mixtures and increased linearly with the composition [3, 5]. However, at one

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point at a higher fiber loading this rule is no longer exist, might caused by lack of wetting of the fiber by the polymer [7]. This study will concentrate on the following parameters (i) fiber dispersion, (ii) fiber matrix adhesion (iii) fiber volume fraction.

2.3.1 Dispersion of fiber in matrix

The primary requirement for obtaining a satisfactory performance from short-fiber composites is good fiber dispersion in the polymer matrix. Good dispersion implies that the fibers are separated from each other (i.e. there are no clumps and agglomerates), and each fiber is surrounded by the matrix [10]. For instance, naturally occurring cellulose fibers agglomerate during mixing due to hydrogen bonding [3]. Pre-treatment of fibers always necessary to reduce the interaction between fiber and matrix. Such pre-treatments include making pre-dispersion at the surface. Pre-dispersion of chopped fibers such as polyester, glass and rayon has been successfully studied by Leo and Johansson [11]. Insufficient fiber dispersion, on the other hand, results in an inhomogeneous mixture of resin-rich areas and fiber-rich areas. This is undesirable because the resin-rich areas are weak and the fiber-rich areas (i.e., clumps) are susceptible to microcracking [10]. Microcracks contribute to inferior mechanical properties of composites. It is therefore important to ensure homogeneous fiber dispersion in order to achieve maximum strength and performance of the composite materials [10].

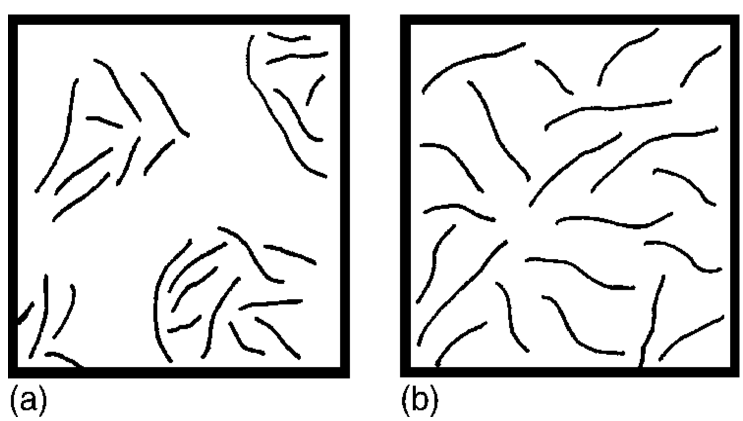

Figure 2: (a) Poor dispersion (b) Good dispersion

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2.3.2 Fiber-matrix adhesion

Fiber to matrix adhesion plays a very important role in the reinforcement of composites with short fibers. During loading, loads are not applied directly to the fibers but to the matrix [10]. To have composites with excellent mechanical properties, the load must be transferred effectively from the matrix to the fibers.

The critical fiber length influences the fiber-matrix adhesion. Fibers that are shorter than the critical length will not carry out their maximum load and this will unable the matrix to function effectively [3]. However if the fibers are beyond the critical length, the fibers will carry an increasing fraction of applied load and this condition might lead to fracture before matrix [7].

Sufficient adhesion, low fiber diameter and high tensile strength allow for short critical fiber length [10]. Good interaction as well as good adhesion can be controlled by either surface treatment applied to the fiber or by the use of additives such as coupling agents [10].

Childress and Selke [11] investigated the effectiveness of several additives in enhancing mechanical properties of wood fiber/high density polyethylene composites. The additives used were ionomer-modified polyethylene (ION), maleic anhydride modified polypropylene (MAPP), and two low molecular weight PP (LWMPP 1) and (LWMPP 2). The effects of these additives on tensile properties, impact strength, creeps as well as water absorption, were evaluated at 1, 3 and 5 percent additive addition. The result shows that the mechanical properties increasing with the increase in additive concentration [11].

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2.3.3 Effects of fiber volume fraction

Like other composite systems, the properties of short-fiber composites are also crucially determined by fiber concentration. Variation of composite properties, particularly tensile strength, with fiber content can be predicted. At low fiber volume fraction, a drastic decrease in tensile strength is usually observed while at higher volume fraction, the matrix is sufficiently restrained and the stress is more evenly distributed [7]. For short fiber composites to perform well, the matrix must be loaded with fibers beyond this critical value [3]. However if the fiber volume fraction is too high, the strength will be decreased due to insufficient matrix material to adhere the fibers together [7].

Garoushi and friends [12] reported that from their studied it is proven, by increasing the fiber volume fraction, improvement in mechanical properties of Fiber-reinforced composite (FRC) is obtained. It has been described by increasing the fiber content the flexural strength increases linearly according to the law of mixtures. It is preferable to define the fiber quantity in the polymer matrix in volume percentage rather than weight percentage. In short fiber composites the length and adhesion of fibers should provide load transfer from polymer matrix to the fibers [12]. The shortest effective fiber length is the critical fiber length.

2.4 Processing of composite material

2.4.1 Mixing

Mixing short fibers into thermoplastic is easy, but to control the processing conditions is quite tedious, since the fibers are processed in the same way as thermoplastic in plastic processing equipments [3]. The main objective of mixing process is to obtain good fiber dispersion. Differed by type of fibers, mixing can be either distributive or dispersive [6]. Distributive improves the randomness of spatial distribution of minor constituents within major base without reducing the size of fiber whereas the dispersive mixing serves to reduce the agglomerate size [6]. Organic fibers naturally performed better under dispersive mixing due to their tendency to agglomerate during the process.

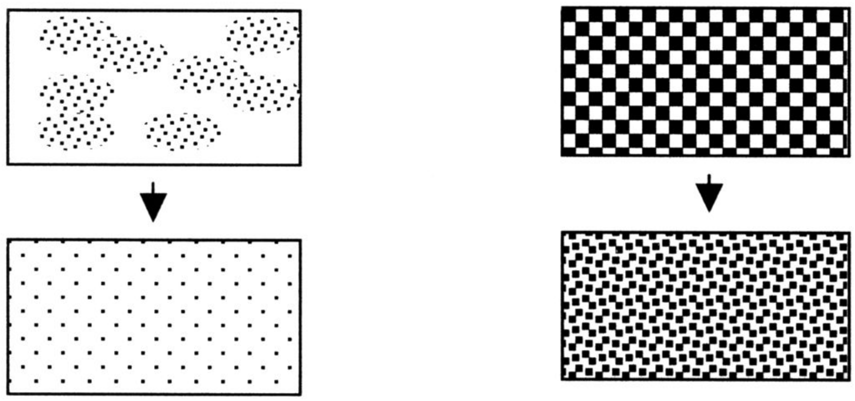

Figure 3: (a) Distributive mixing and (b) Dispersive mixing

2.4.2 Injection molding of composites

Injection molding is the most common and widely used manufacturing process which specifically suitable for high volume production of thermoplastic resin parts or reinforced with fibers [7]. Solid pellets of resin containing the fiber and sometimes fillers are fed through a hopper into a heated barrel with a rotating screw [6]. The screw's function is to mix the reinforcement and the resin and also generate heat by viscous shearing against the barrel [6]. Then the screw will acts as a piston by forcing the mixture of fibers, fillers and molten resin under high pressure [6, 7]. The mixture will later run into a matched-metal mold where the polymer solidifies, freezing the orientation and distribution of fibers and fillers. The composite part will be ejected after it solidifies.

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2.4.3 Injection molding processing parameters

There are more than 100 parameters in the molding process that must be controlled to ensure the proper manufacture of a product. All fall into one of four critical categories: temperature, pressure, time and distance.

2.4.3.1 Temperature

In injection molding process, optimum temperature distributions need to be obtained to avoid excessive residual stresses that may lead to warpage [6].

Temperature of material: The primary temperature of concern is the temperature at which the plastic material must be heated before it is injected into a mold. All materials have range of temperatures within which they are most efficiently injected while still maintaining maximum physical properties.

Temperature of mold: Another important factor in determining the strength of thermoplastic material properties. This is because when the material is first heated, the molecules are disconnected from each other and allowed to move about freely. As the material cools, these moleculues must attach themselves to each other again to regain the maximum strength. If they are cooled downs too quickly, they stop moving before they are fully connected and the result is a product with less than optimum physical strength. So it is important to cool the plastic at a rate slow enough to allow the material to each proper physical strength, but fast enough to minimize cycle temperature.

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2.4.3.2 Pressure

Pressure is required for a variety of reasons in injectionmolding process. Pressure for the process is provided by the hydraulic oil system within the molding machine and a seriesof control valves, regulators and directional valves. The specific requirements for the various pressures are as follows:

Injection pressure: It is the primary pressure used for the injection molding process. It can be defined as the amount of pressure required to produce the initial filling of the mold cavity. (Mold cavity is the opening in the mold that will be filled with thermolastics to form the molded product). Meanwhileinitial filling represents approximately 95% of total filling of cavity image.

Holding pressure: Holding pressure is applied at the very end of the primary injection stroke and is used for the final 5% filling of the cavity. It is called holding pressure because it holds the pressure against the cooling plastic in the cavity while the plastic solidifies. This helps to ensure a dense part molded with uniform pressure and controlled shrinkage.

Clamp pressure: Clamp pressure can be defined as the amount of pressure required to hold the mold closed against injection pressure. The clamp unit of a molding machine can be mechanically or hydraulically activated, and this pressure is applied against the mold that forms the plastic product. If the clamp pressure is too low, the mold will blow open during injection and if the clamp pressure is too high the mold may collapse from total force applied.

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2.4.3.3 Time

Injection time: The amount of time required for injection activities depends on how much material is being injected, the viscosity of the material and the percentage of the machine's barrel capacity that is being utilized. The filling time also need to be controlled since if it is too slow, premature solidification may prevent complete filling and if it is too rapid, thermal degradation may occur due to the heat released from viscous dissipation which is proportional to the shear rate [6].

CHAPTER 3

METHODOLOGY

1.5 Preparation of CFF

The chicken feathers are first washed with hot water to remove the dirts which stick togeher with the chicken feather. Later, the chicken feather is left to dry under the sun for 4 hours. For further treatment, the chicken feather is soaked with organic solvent (95% ethanol) for a day. The feathers are then drained. Any residual solvent is removed by drying, such as in a forced air oven at a temperature range of 80°C to about 130° C for about a day. The dried CF is then left in room temperature (27°C) for a day.

Figure 4: Dried CF at after chemical treatment

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Following the cleaning process, the feathers are grinded by using grinder machine as in Figure 5 to obtain short fibres.

Figure 5: Grinder machine

Different percentage of volume fraction of fibers ranging from 2.5% vol. to 10.0% vol. is compounded with random orientation using *Brabender* extruder machine to obtain the CFF/PP composites in pelletized form. The extrusion is performed at 50 rpm for a constant time of 15 minutes for each batch. Set temperature is maintained at 190°C which is the processing temperature for PP. After removal from the *Brabender*, the resins are injection molded to get the samples in the dog bone shape. The process is done at 140 MPa with 30 seconds cooling time per sample.

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1.5.1 Calculation of fiber volume fractions

Density of fiber reinforcement, $\rho_r = 0.89$ g/cm^3 [14]

Density of PP matrix, $\rho_m = 0.902$ g/cm^3

Basis Mass: 500 g

Table 2: Volume of CFF/PP

No.	% vol. of CFF	Volume of CFF (cc)	%vol. of PP	Volume of PP (cc)
Controlled	0.0	0.0	100	554.32
Batch PC-1	2.5	14.04	95	540.47
Batch PC-2	5.0	28.08	90	526.61
Batch PC-3	7.5	42.12	85	512.75
Batch PC-4	10.0	56.16	80	498.89

Table 3: Weight of experimental materials

No.	% vol. of CFF	Weight of CFF (grams)	%vol. of PP	Weight of PP (grams)
Controlled	0.0	0.0	100	500.00
Batch PC-1	2.5	12.50	95	487.50
Batch PC-2	5.0	25.00	90	475.00
Batch PC-3	7.5	37.50	85	462.50
Batch PC-4	10.0	50.00	80	450.00

1.6 Preparation of composite feedstock

In this study, four batches with five numbers of samples each and 1 batch is prepared for pure PP. The CFF are reinforced at 2.5% volume fractions up to 10%.

Different percentage of volume fraction of fibers ranging from 2.5% vol. to 10% vol. is compounded with random orientation using Brabender extruder machine to obtain the CFF/PP composites in pelletized form. The extrusion is performed at 50 rpm.

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Set temperature is maintained at 190°C which is the processing temperature for PP. After removal material from extruder, the resins are injection molded to get the samples in dog bone shape. The process is performed at 140 MPa with 30 seconds cooling time per sample.

1.7 Mechanical Testing

Tensile test is conducted according to ASTM D638. It is a test where a measurement of ability of a material to withstand forces that pulls it apart and to what extent the material stretches before breaking. From stress-strain diagram, tensile properties like Young's Modulus, percentage elongation and tensile strength can be obtained. The stiffness which is represented by Young's Modulus can also be determined from the stress-strain diagram.

Tensile test was carried out by using Universal Testing Machine (Lloyd LR 50kN) as shown in Figure 6. The test procedure was based on the standard operating procedures (SOP) manual provided. There were 25 samples prepared for this test. Detail dimension of the specimen is shown in Figure 7. The testing was done in standard laboratiry temperature of 23°C ± 2°C.

Before conducted the test, the gage length is marked and recorded manually since there is no extensometer. The samples were then positioned vertically in the grips of the testing machine and the grips were tightened firmly inorder to avoid any slippage. The precise resultsof 5 tested specimens were then chosen for each batch of fiber content and for pure PP.

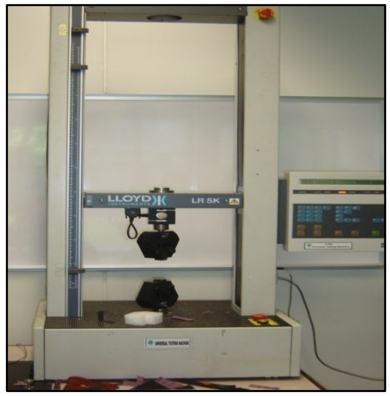

Figure 6: Universal Testing Machine (Lloyd LR 50kN)

Dimension of samples;

Gage Length: 81.0mm

Thickness: 4.0mm

Overall Length: 210mm

Width of gage length section: 10mm

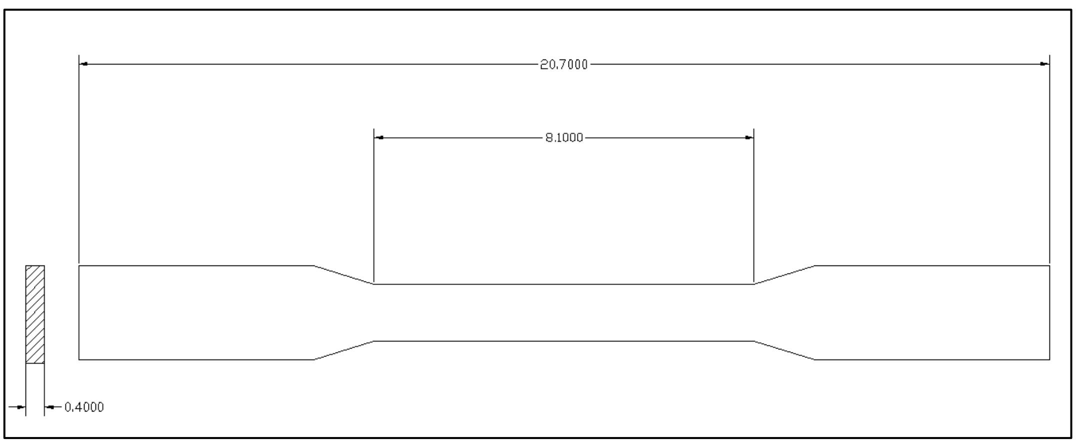

Figure 7: Dimension of samples

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When tensile test is conducted, the results obtained are recorded includes the change in gage length by using vernier calliper. These data are subsequently converted into stress and strain diagram. The stress-strain curve is analyzed further to extract properties of materials.

1.8 Material Characterization of Composite

Magnification and internal visualization by SEM is used as the analysis techniques for the study. It is used simply to magnify the specimen, to visualise its internal structure, and to gain knowledge as to the distribution of elements within the specimen and their bonding.

The fracture surfaces of the tensile specimens for all CFF/PP reinforced composites are examined by using SEM [3]. Images obtained from SEM are used to further study the microstructural behavior of CFF/PP composite.

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CHAPTER 4
RESULTS & DISCUSSION

4.1 Introduction

This chapter covers analysis and discussion of the data that have been collected throughout the testing. The tensile test was carried out on the samples based on ASTM D638-03 by using Universal Testing Machine (Lloyd LR5K UTM) at a constant speed of 5 mm/min for each sample. The machine is controlled by Lloyd Bluehill software and the procedures were based on standard operating procedures manual provided by the manufacturer. The precise five tested result were chosen for each fiber contents of CF in polypropylene matrix and also for the control samples. All data showed in graphical presentation to facilitate the data analysis. The four main properties observed were stiffness, Young's Modulus, tensile strength and percentage of strain at break. The properties are interpreted from the stress-strain diagram produced from each samples.

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4.2 Effects of CFF on mechanical properties of PP

4.2.1 Stiffness

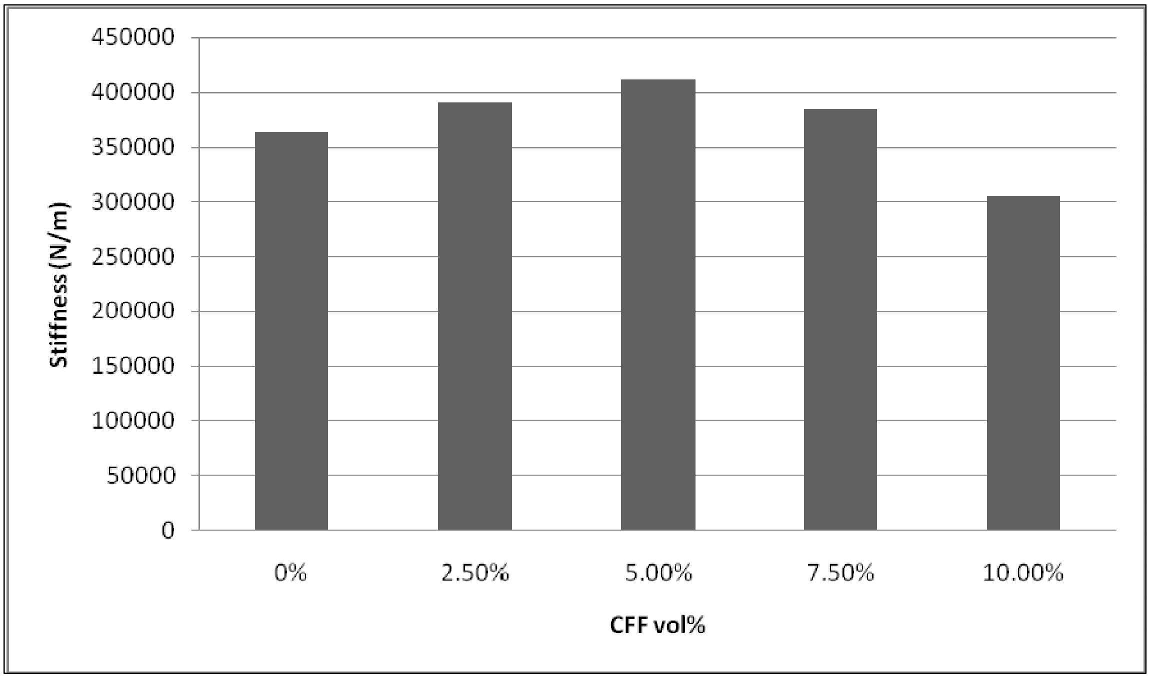

Figure 8: Effect of CFF on Stiffness

Figure 8 shows the effects of various percentages of volume fractions of CFF on stiffness of composite. The unreinforced PP gives 36,400 N/m where most of the test samples experienced necking behavior before failed. The necking behavior indicates the ductile nature of PP. The stiffness increases from 0%-5% and the property is at the highest at 5.0% vol. of CFF whereby it increases by 12.9%. However the stiffness starts to decline afterward and at 10.0% vol. of CFF, it is at the lowest with only 30,500 N/m. At 10.0% vol.of CFF, the increases of fiber addition and the poor fiber dispersion might affect the result.

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4.2.2 Young's Modulus

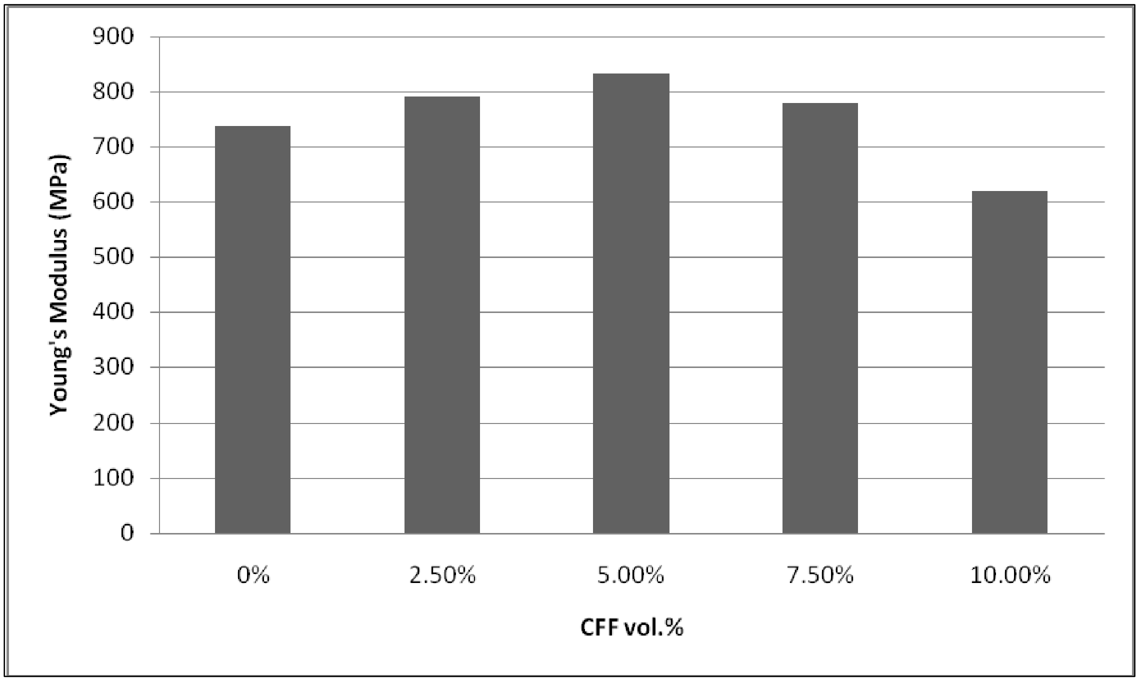

Figure 9: Effect of CFF on Young's Modulus

Figure 9 shows the effects of various percentages of volume fractions of CFF on Young's Modulus of the samples. The unreinforced PP gives 736.96 MPa which testifies the fact that ductile sample has low modulus. The modulus increases from 0% - 5.0% and the property is at the highest at 5.0% vol. of CFF whereby it increases by 12.9%. The increase is similar with the stiffness since they are more likely equivalent. However, the modulus starts to decline afterward and at 10.0% vol. of CFF, the increases of fiber and poor fiber dispersion might affect the result.

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4.2.3 Tensile Strength

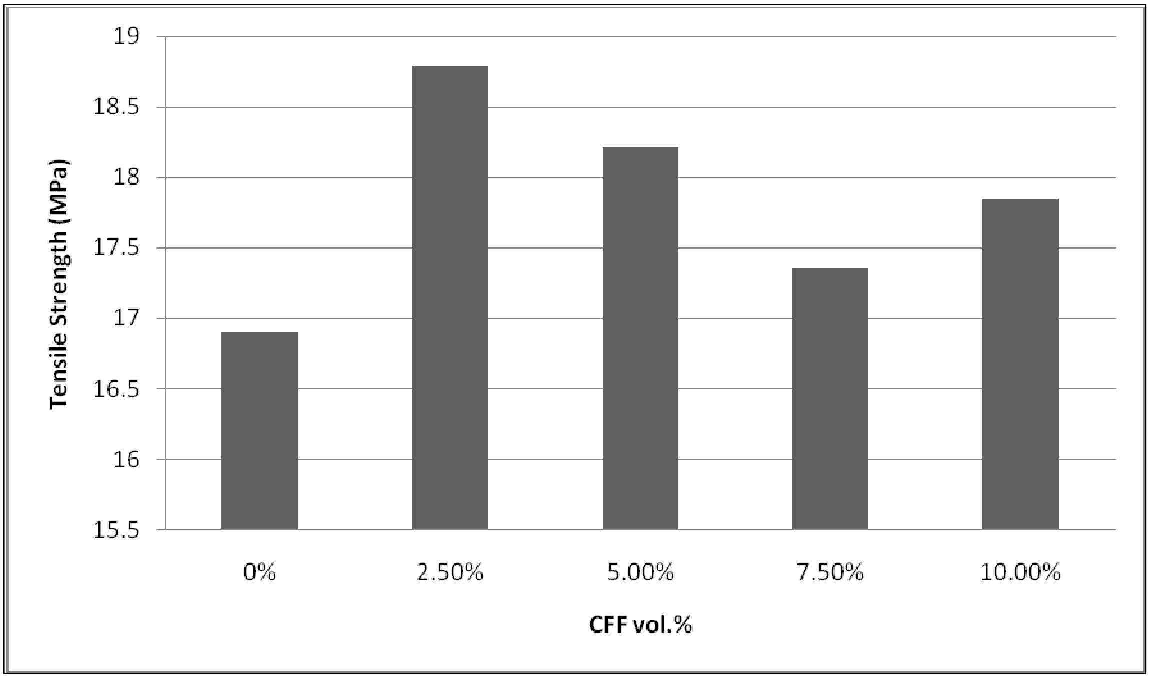

Figure 10: Effect of CFF on Tensile Strength

Figure 10 shows the effect of various percentages of volume fractions of CFF on tensile strength of test samples. The unreinforced PP gives the smallest reading of 16.9 MPa which testifies the fact that ductile sample deforms at lower force compared to the reinforced samples due to necking phenomenon. However the highest tensile strength occurs at 2.5% vol. of CFF where the increase is 11.2%. At 5.0% vol.of CFF, the tensile strength is 18.2 MPa. The sample for 10.0% vol. of CFF shows unique property whereby although it gives small stiffness and modulus readings, 17.8 MPa is required for deformation to occur.

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4.2.4 Percentage Strain at Break

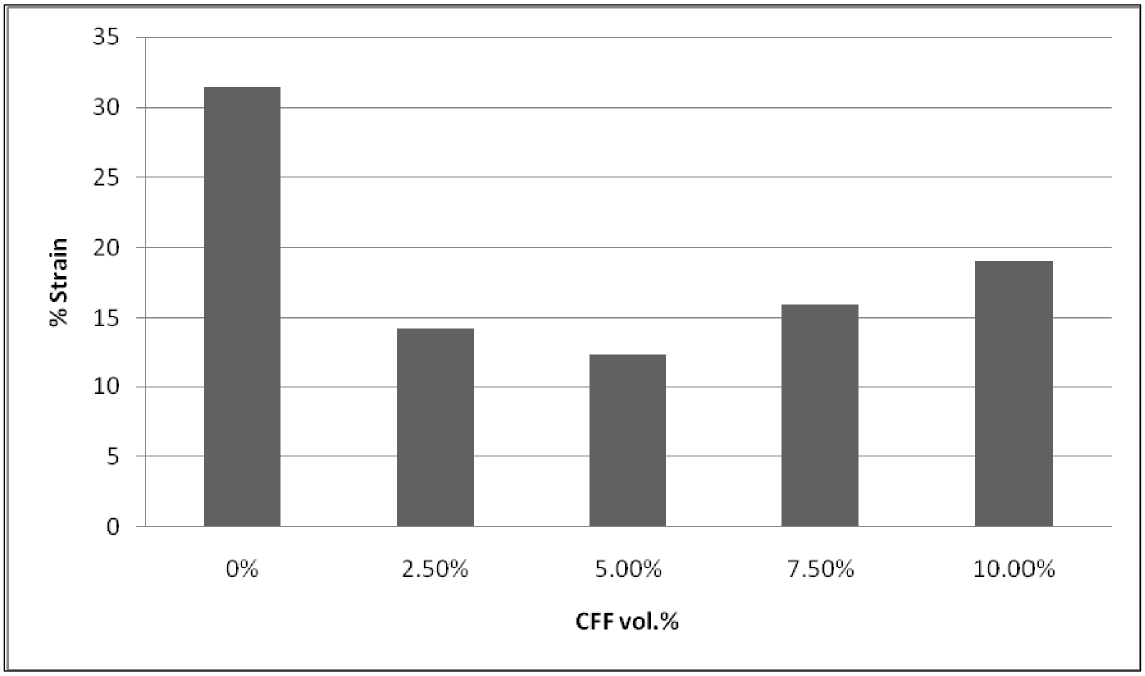

Figure 11: Effect of CFF on % Strain

Figure 11 shows the effect of various percentages of volume fractions of CFF on percentage of strain at break of the samples. The unreinforced PP gives the highest percentage of strain at break with 31.4% while the lowest percentage occurs at 5.0% vol.of CFF with 12.3%. The percentage declines from 0% - 5.0% and after that the reading increase back. The result fits the property of the samples where the pure PP without fiber addition is ductile in nature and thus it deforms greater compared to the reinforced fiber samples. Samples at 5.0% are proved to be the most brittle samples and thus the deformation at break is the smallest.

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4.3 Microscopy

The test results show that the reinforcement of PP matrix can be achieved with CFF. In Figure 9, there is an observed increase in Young's Modulus of 12.9% over the pure PP samples. To further investigate the orientation and CFF/PP interactions, the fracture surfaces of tensile bars are imaged using SEM. Initially, PP is in ductile nature as shown by the localized polymer drawing in SEM images in Figure 12 at 100% PP. However, at greater fiber volume fractions (7.5 vol.%), the values declined. Based from SEM image in Figure 13, it can be observed that CFF shows non-uniform cross-section area at 7.5 vol.% of CFF. These might be the cause that contributes to reduction in modulus. Unlike uniform synthetic fibers, irregular shape of fibers, their capability to support stress from matrix is rather poor.

As the fiber loading increases, the presence of voids and broken fibers were also observed as in Figure 14. The broken fibers indicate insufficient fiber-matrix bond which unable the composite to withstand higher stress loading. The broken fibers might be the result of the twin screw actions crushing the fiber during extrusion process. Observation of Figure 14 shows that the voids are about the diameter of the fibers so the voids may represent the volume once by the fibers. It would seem that the voids are the result of processing anomalies. Figure 15 shows some polymer/fiberinteractions as shown by the polymer adhering to the fiber at some degree. Also shown in Figure 15 is the onset of for the yielding, $\varepsilon_{y.}$ The yield strain is indicative of a transition of material from ductile to brittle behavior.

Referring to Figure 12, at 100% vol. of PP, the fracture topography is ductile with localized drawing of polymer. As the fiber loading increases; the fracture topography becomes flatter with less localized polymer drawing.

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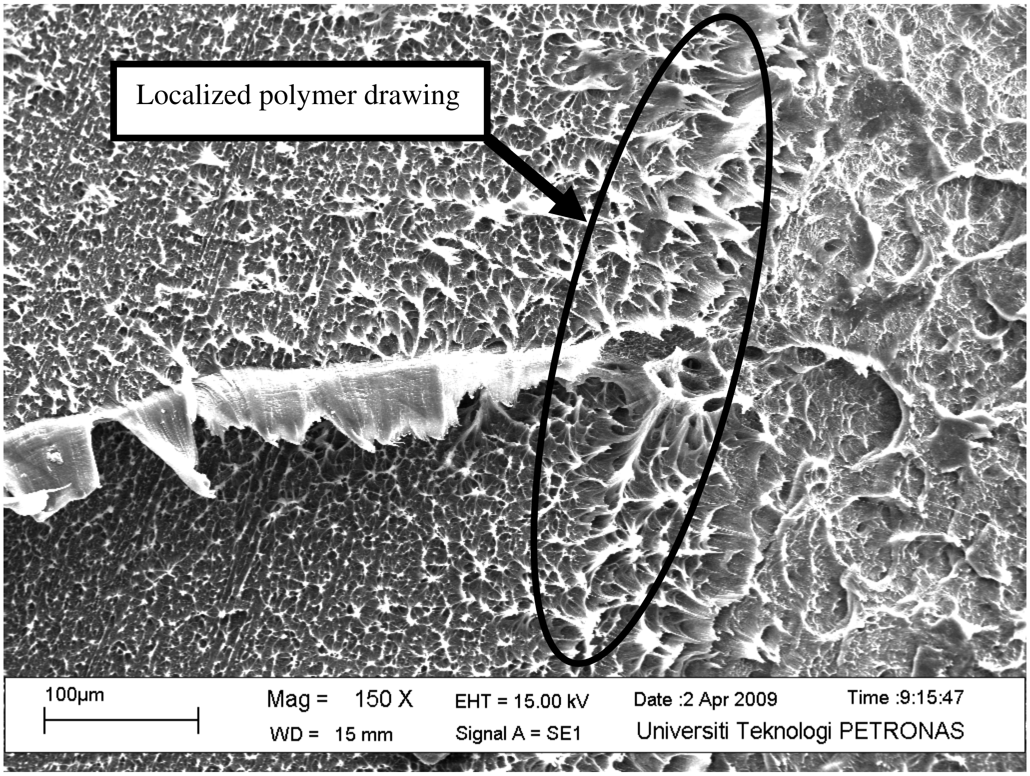

Figure 12: Localized polymer drawing at 100 vol.% PP at 100µm scale bar

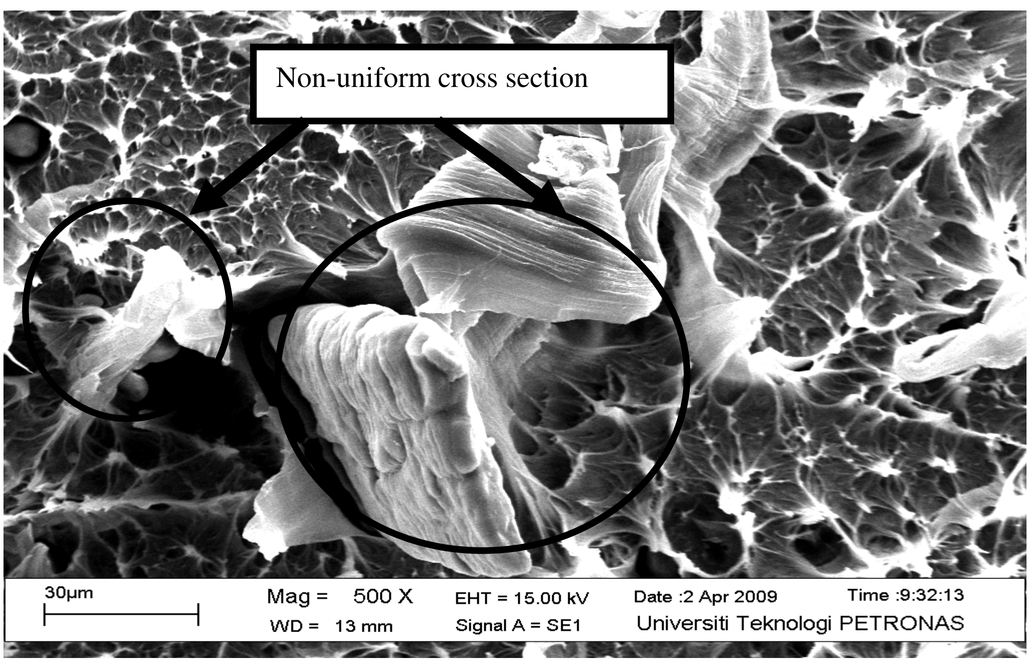

Figure 13: Non-uniform cross section at 7.5vol.% of CFF at 30 µm scale bar

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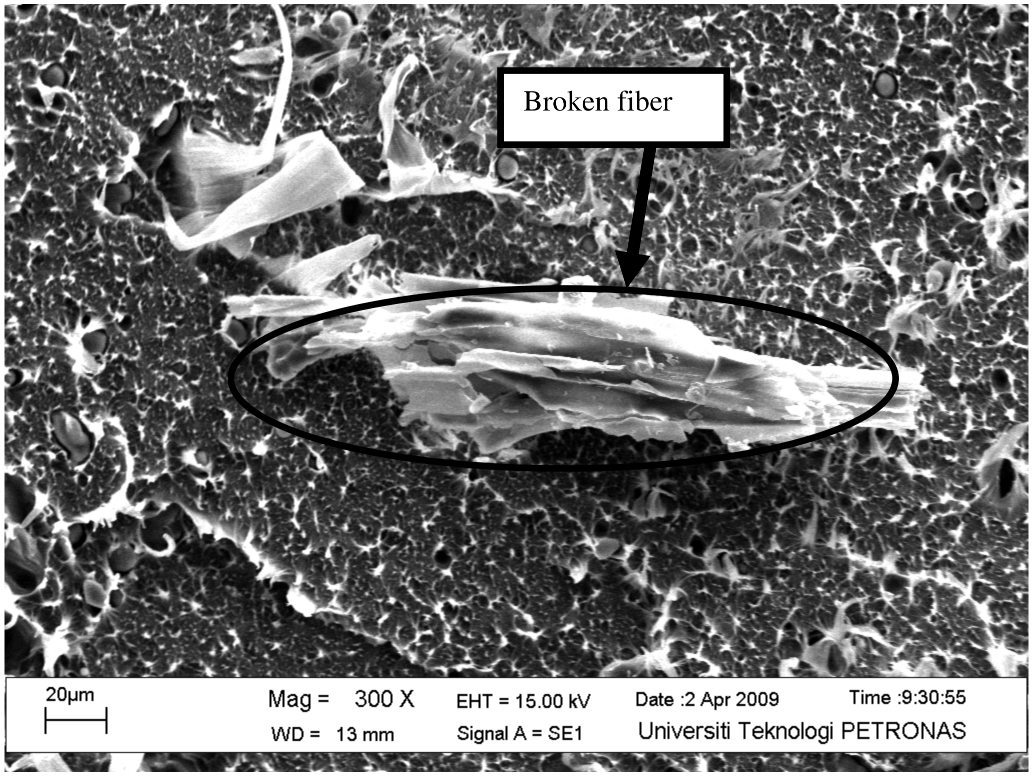

Figure 14: Broken fiber at 7.5 vol.% CFF at 20µm scale bar

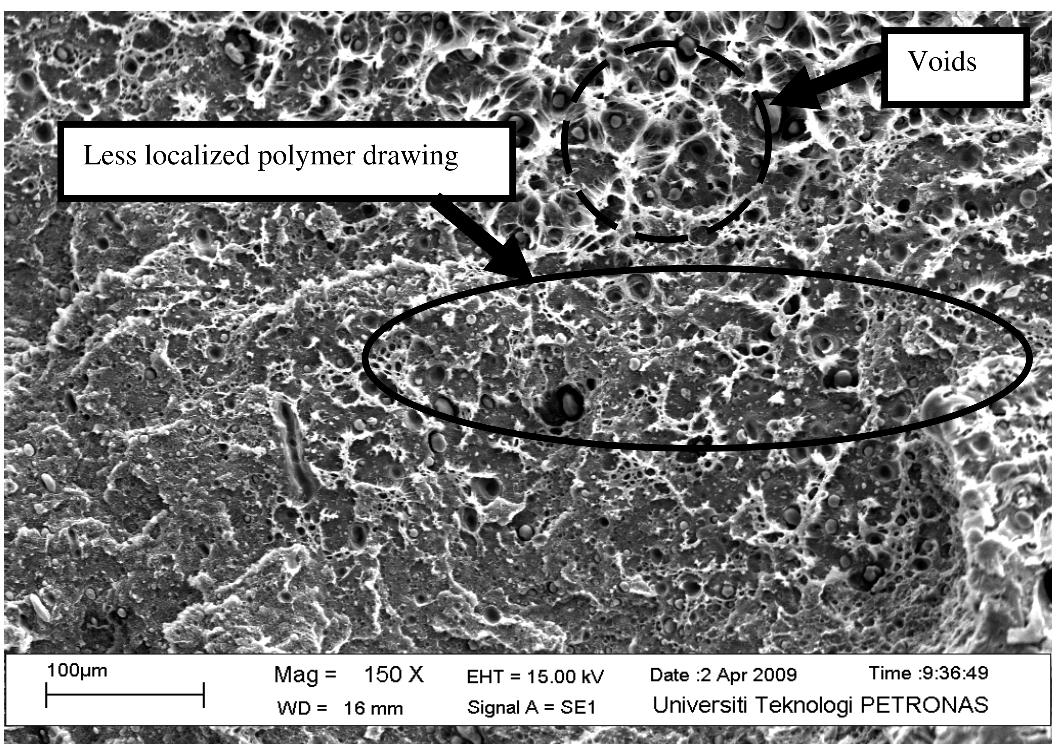

Figure 15: 10.0 vol.% CFF at 100 µm scale bar

CHAPTER 5

CONCLUSION

Results of the study showed that Chiken Feather Fiber gives contribution as reinforcement to the mechanical properties of CFF reinforced PP composite. Eventhough the result of this study showed that the tensile strength did not significantly improve due to the increasing volume fraction of the fiber, the modulus of elasticity was improved to 12.9%.

From observation of all results, the optimum fiber content which yields the highest modulus of elasticity which indicates improvement in the stiffness of PP composite is at 2.5% vol. of CFF. This is because at higher fiber content, PP matrix cannot accommodate every fiber and thus leaving voids. The voids are undesireable since they could affect the other properties. In addition, the presence of voids made the fibers easier to exposed to the environment and get degraded.

The poor fiber dispersion also contributes to the decrease in strength of the composites. A more uniform distribution of fibers may greatly a good solution to get an improved strength of PP composites with CFF as reinforcement material. During the processing either during the extruding or molding, the fibers have been missalligned which further affect the strength of the fiber since it is not in a straight allignment.

As a conclusion, this study suggests that chicken feather is potentially attractive thermoplastic reinforcement material. The reinforced composite may be further improved by using suitable coupling or bonding agents.

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APPENDICES

APPENDIX 1: GANTT CHART

Milestone for the First Semester of 2 Semester Final Year Project

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SW	EW
1	**Selection of Project Topic**																
	-Propose Topic																
	-Topic assigned to students																
2	**Preliminary Research Work**																
	-Introduction																
	-Objective																
	-List of references/literature																
	-Project planning																
3	**Submission of Preliminary Report**																
4	**Project Work**																
	-Reference/Literature																

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	-Practical/Laboratory Work																
5	**Submission of Progress Report**									29/3							
6	**Project work continue**																
	-Practical/Laboratory Work																
7	**Submission of Interim Report**													26/4			
8	**Oral Presentation**																

SW: Study Week

EW: Exam Week

Milestone for the Second Semester of 2 Semester Final Year Project

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SW	EW
1	**Project Work Continue**																
	-Practical/Laboratory Work																
2	**Submission of Progress Report 1**					12/2											
3	**Project Work Continue**																
	-Practical/Laboratory Work																
4	**Submission of Progress Report 2**									29/3							
5	**Project work continue**																
	-Practical/Laboratory Work																

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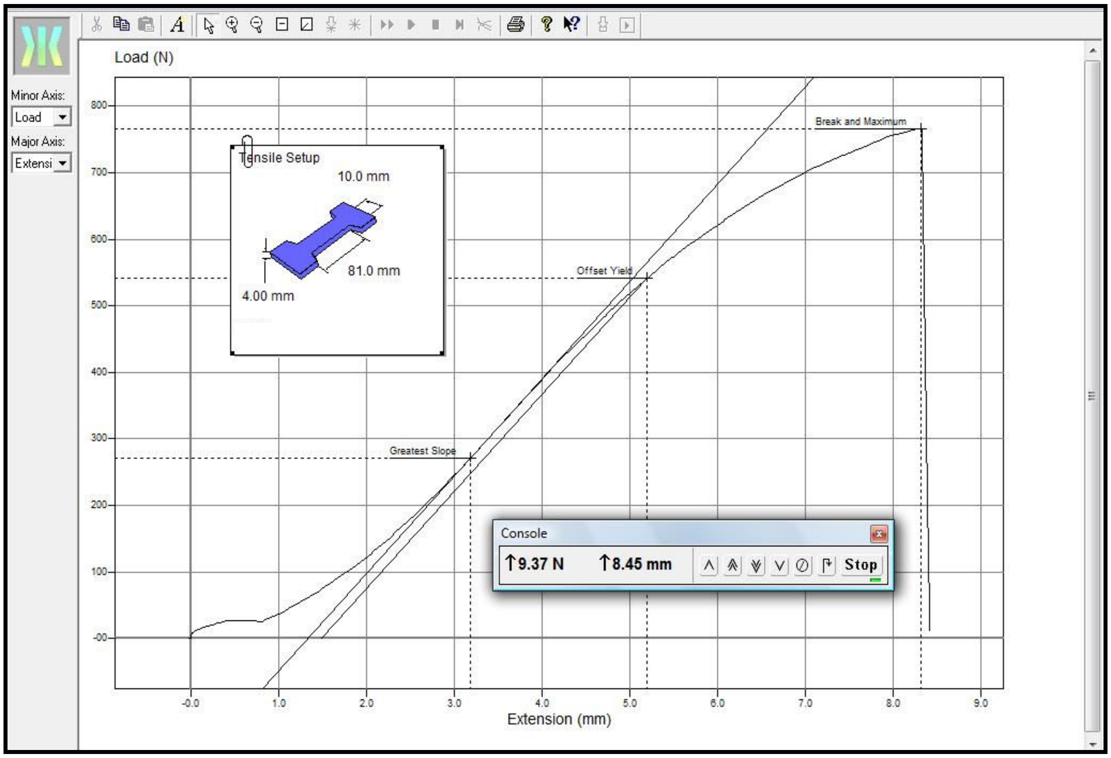
6	**Submission of Dissertation Final Draft**													26/4			
7	**Oral Presentation**																
8	**Submission of Project Dissertation (Hardbound)**																31/5

APPENDIX 2: Load vs. Extension for 2.5 vol.% CFF



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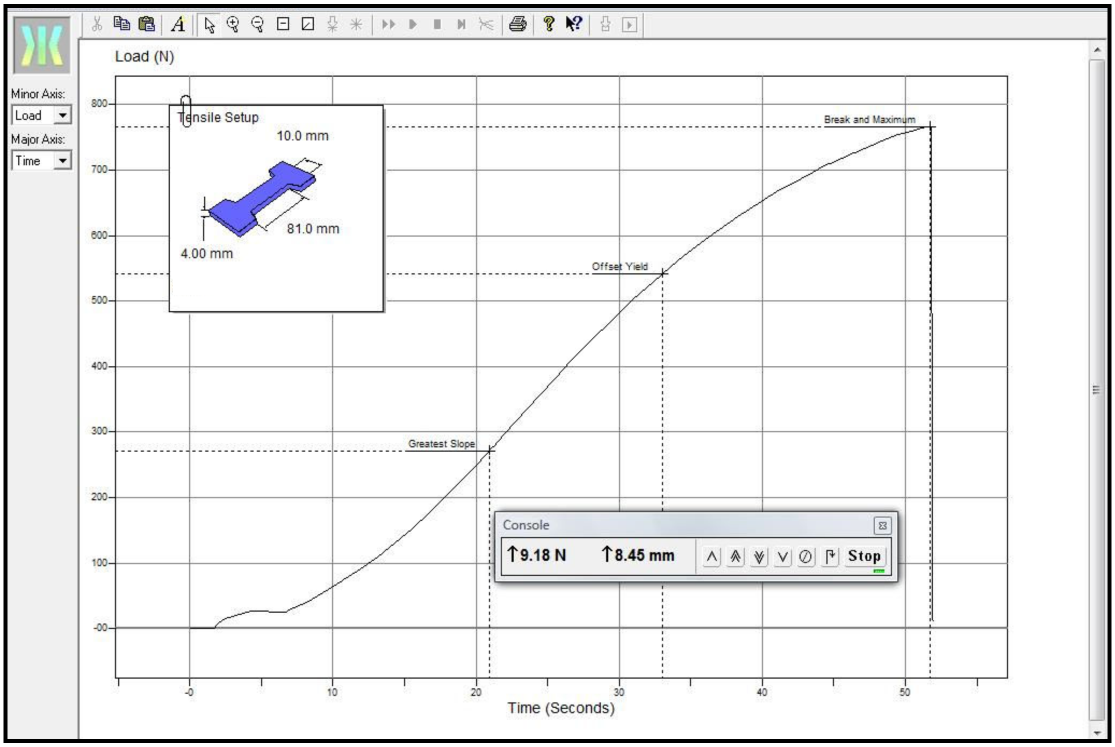
APPENDIX 3: Load vs. Time for 2.5 vol.% CFF



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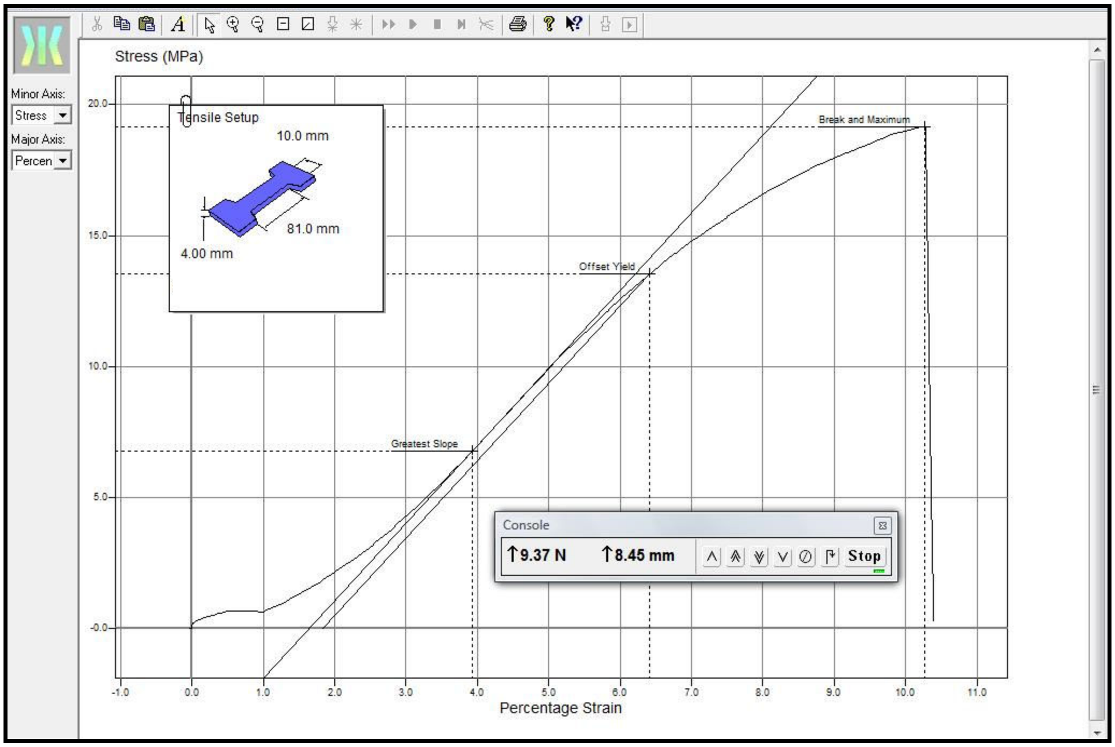
APPENDIX 4: Load vs. Percentage Strain for 2.5 vol.% CFF



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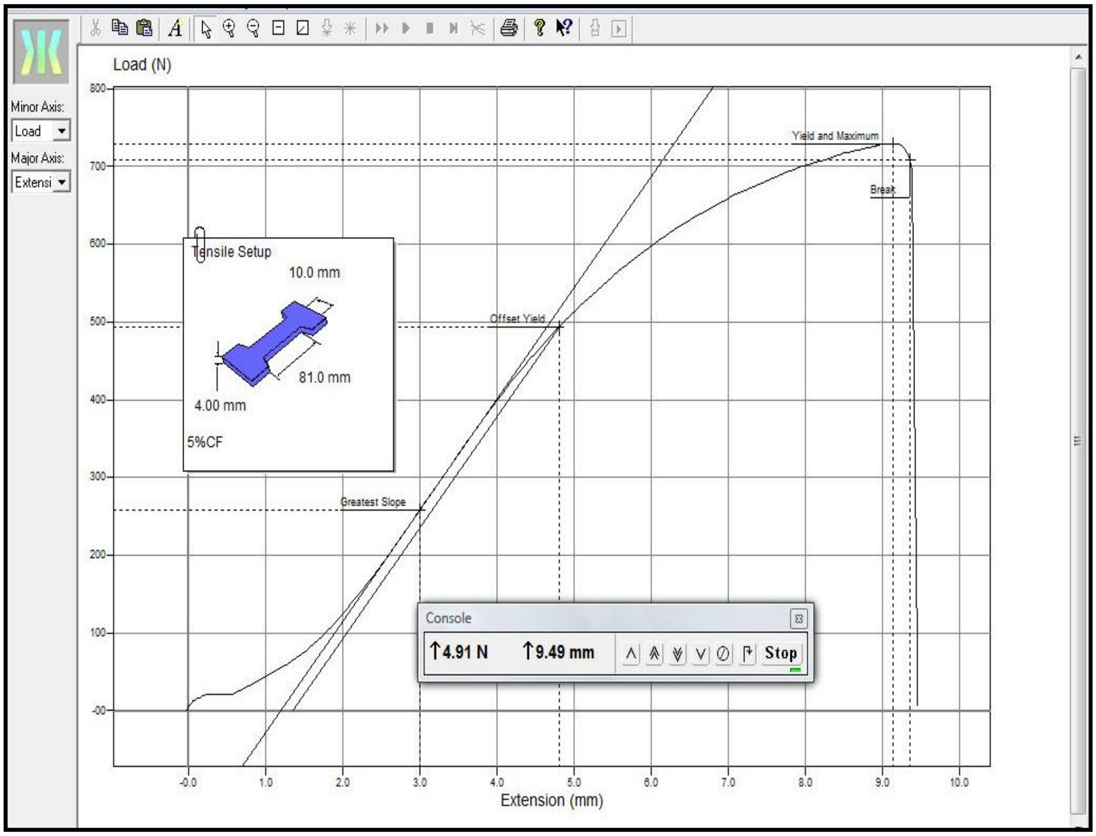
APPENDIX 5: Load vs. Extension for 5.0 vol.% CFF



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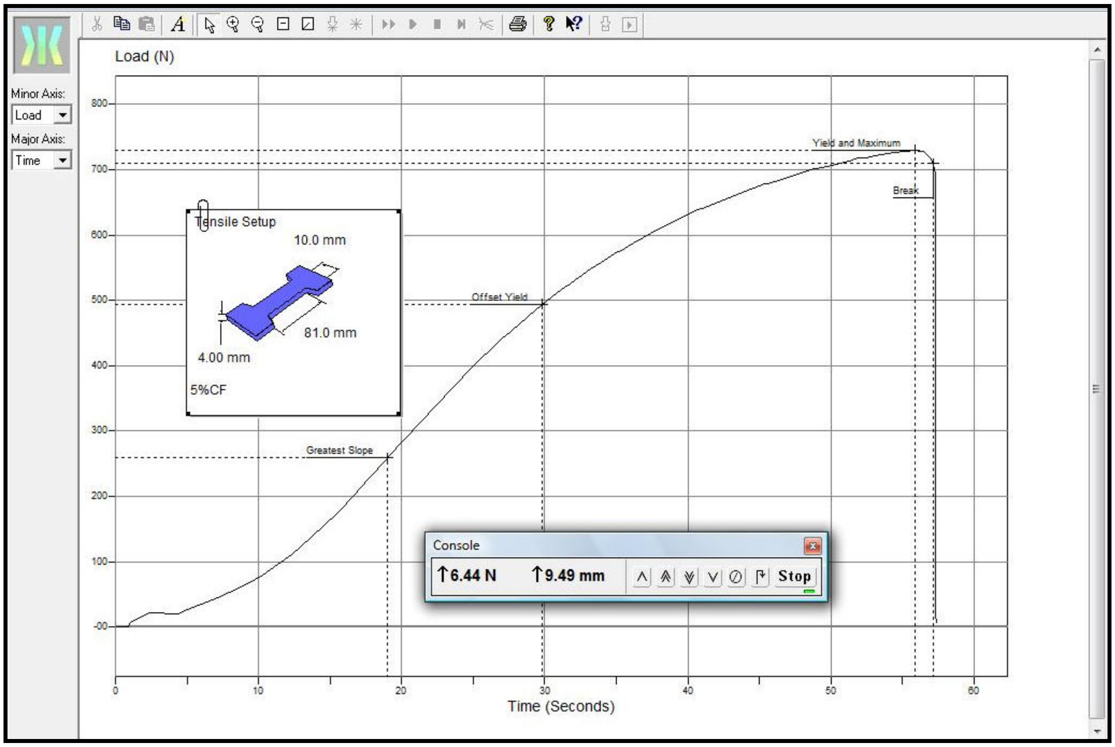
APPENDIX 6: Load vs. Time for 5.0 vol.% CFF



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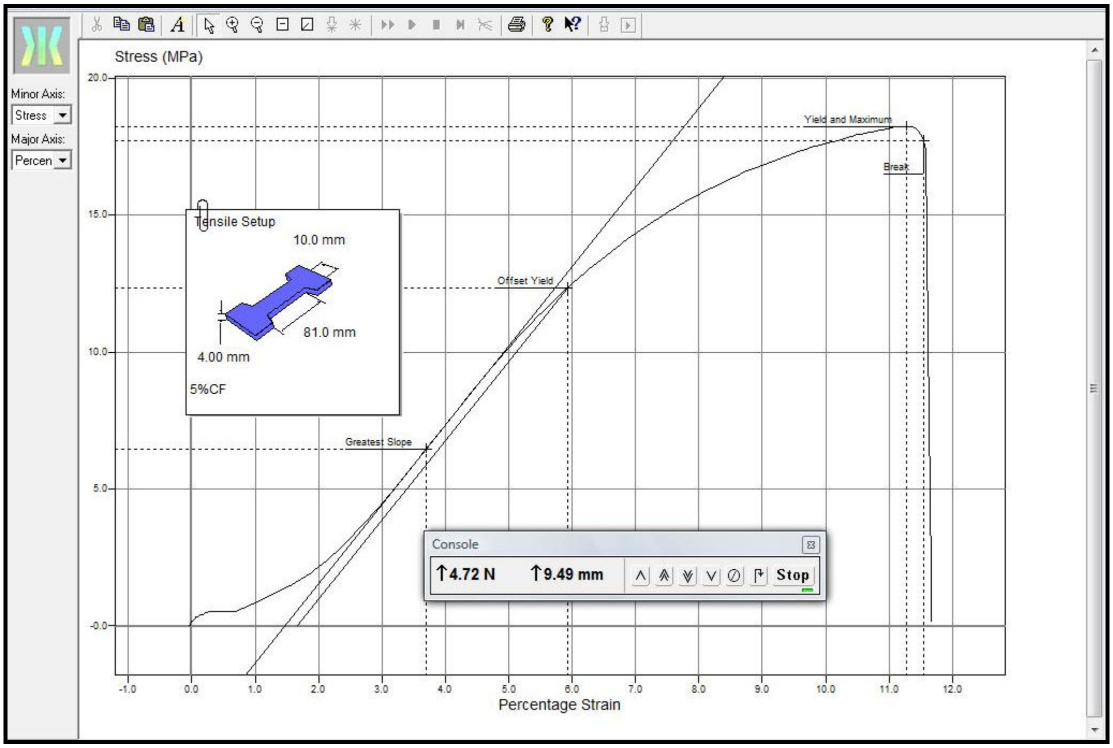
APPENDIX 7: Stress vs. Percentage Strain for 5.0 vol.% CFF



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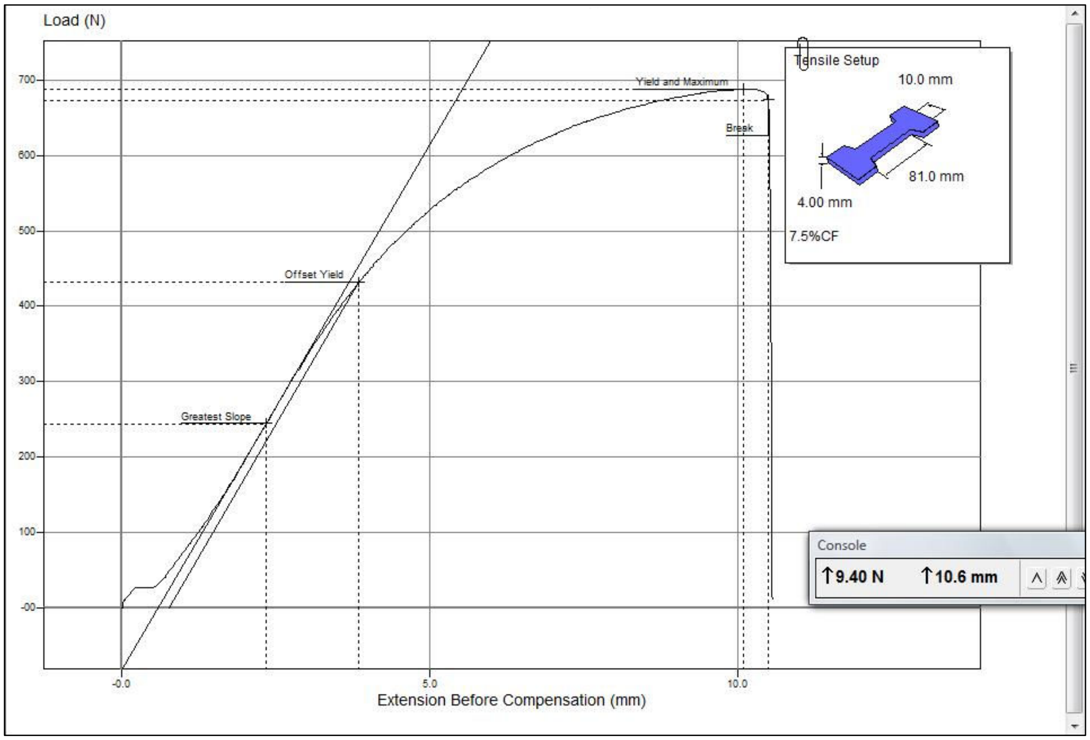
APPENDIX 8: Load vs. Extension for 7.5 vol.% CFF



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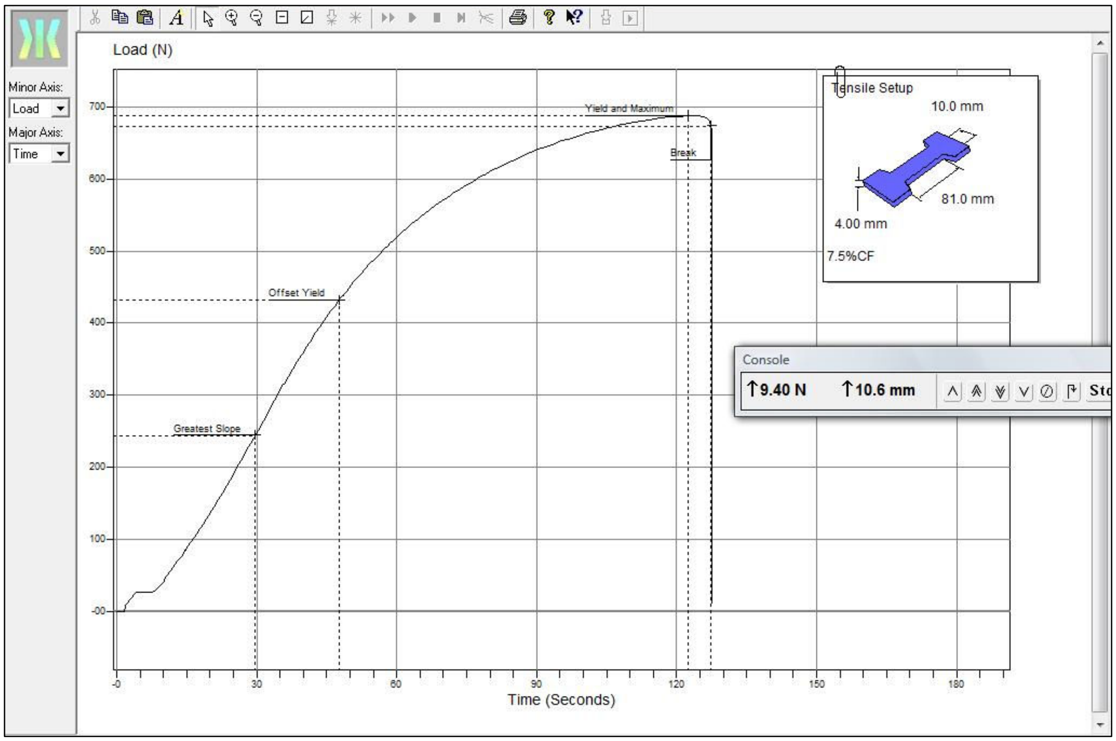
APPENDIX 9: Load vs. Time for 7.5 vol.% CFF



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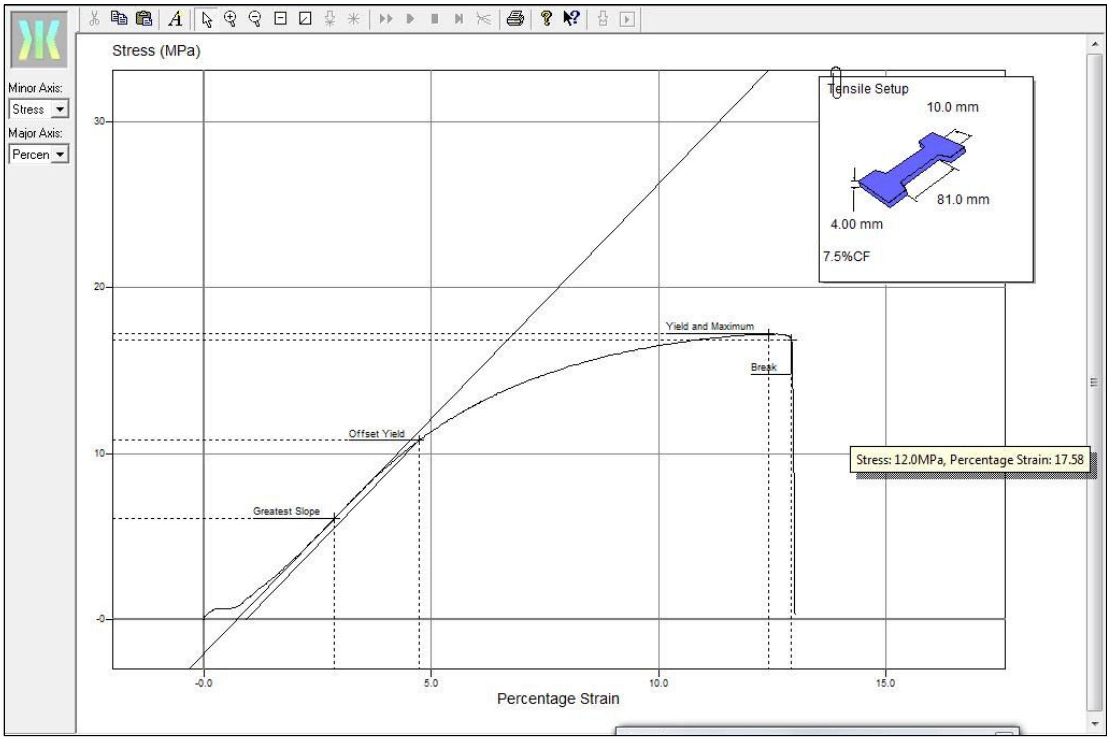
APPENDIX 10: Load vs. Percentage Strain for 7.5 vol.% CFF



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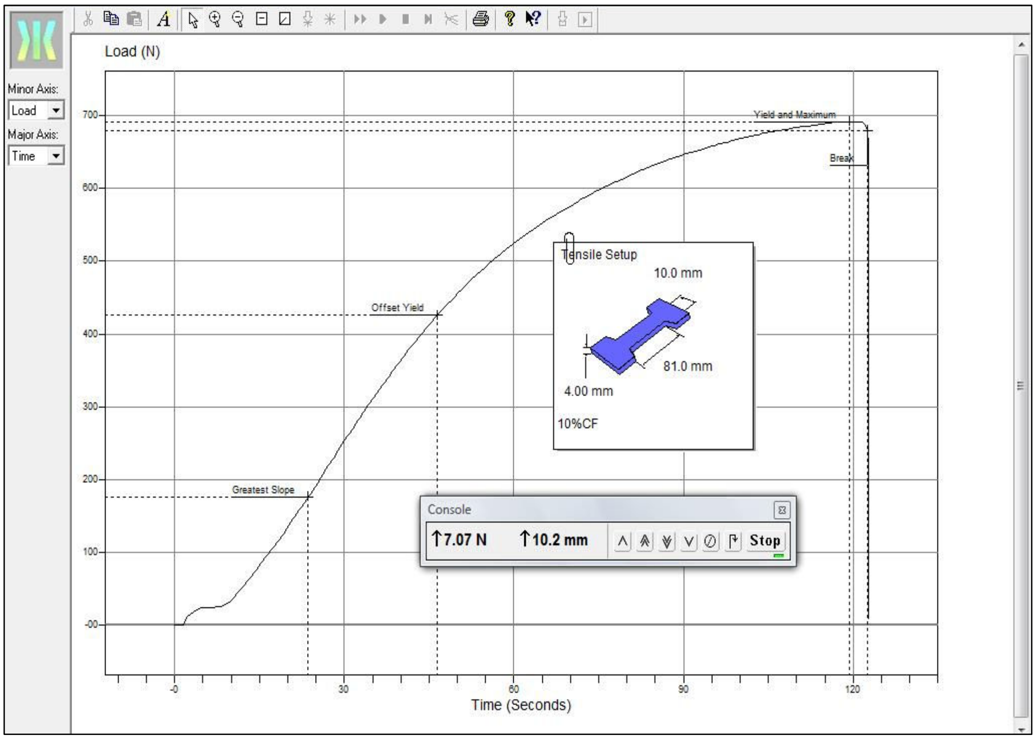
APPENDIX 11: Load vs. Extension for 10.0 vol.% CFF



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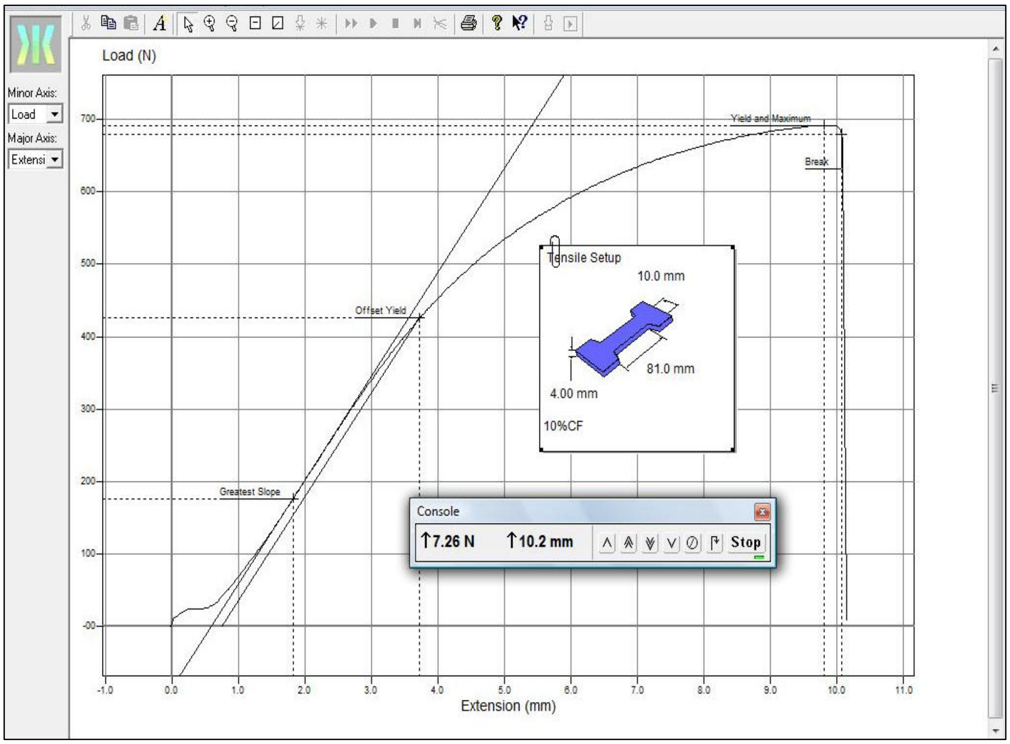
APPENDIX 12: Load vs. Time for 10.0 vol.% CFF



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APPENDIX 13: Load vs. Percentage Strain for 10.0 vol.% CFF